In the Claims

1. (Currently amended) Space-time coding apparatus comprising:

   (a) a data input,

   (~~d~~b) a plurality of signal outputs couplable to a respective plurality of transmit antennas,

   (~~b~~c) a trellis encoder implemented using a convolutional encoder and arranged to receive data from the data input and to produce encoded data in the form of code symbols,

   (~~c~~d) a modulator arranged to map the encoded data to predetermined modulation symbols, and

   (~~d~~e) a de-multiplexer arranged to de-multiplex the modulation symbols to the signal outputs.

2. (original) Apparatus according to claim 1 wherein the convolutional encoder is arranged to generate two code symbols for each data bit input to the trellis encoder, and wherein the two code symbols are alternately switched to an output of the trellis encoder.

3. (original) Apparatus according to claim 1, wherein the data input receives binary data which is grouped into four-bit data blocks, each block representing a single trellis transition, and the convolutional encoder is arranged to produce eight 1-bit code symbols for each four-bit data block, the modulator being arranged to map the eight code symbols to four QPSK symbols to form a single space-time symbol.

4. (currently amended) Apparatus according to claim 1 wherein the rate of the convolutional encoder and ~~the~~a modulation alphabet of the modulator is such that the number of modulation symbols produced for each trellis transition is greater then the number of signal outputs so that more than one space-time

symbol is produced for each trellis transition, whereby the apparatus is arranged to produce multidimensional space-time codes.

5. (original) Apparatus according to claim 1, wherein the data input receives binary data which is grouped into four-bit data blocks, each block representing a single trellis transition, and the convolutional encoder is arranged to produce sixteen 1-bit code symbols for each four-bit data block, the modulator being arranged to map the sixteen code symbols to eight QPSK symbols to form two space-time symbols.

6. (currently amended) A method of space-time encoding comprising:[[-]]

(a) receiving a stream of data at an input,

(b) trellis encoding the data stream using a convolutional encoder operable to sequentially group data to provide coded bits,

(c) outputting the encoded data to a modulator,

(d) operating the modulator to map the encoded signals to QPSK symbols to provide modulated signals, and

(e) operating a de-multiplexer to switch the modulated signals to a set of signal outputs.

7. (original) A method according to claim 6 wherein the input receives binary data and the convolutional encoder groups sequentially input data into quaternary groups, which are processed by the encoder to provide eight-bit data groups which are subsequently converted to QPSK symbols.

8. (original) A method according to claim 6 wherein the trellis encoder comprises a convolutional encoder having a shift register with two parts operable to generate two code signals for each data bit input to the trellis encoder, wherein the code signals are encoded by a generator function, wherein the two coded signals are switched to an output of the encoder.

9. (currently amended) A method of space-time encoding a data stream comprising the steps of:[[-]]

(a) trellis encoding a data stream using an optimal binary convolutional code of predetermined constraint length,

(b) modulating the encoded data by mapping the encoded data stream to modulation symbols selected from a predetermined modulation alphabet, and

(c) de-multiplexing the modulation symbols to a plurality of transmit antennas.

10. (currently amended) A method of estimating complex channel gain in a space-time communications system comprising the steps of:[[-]]

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(a) generating an initial~~, relatively coarse~~ estimate of channel gain,

(b) receiving space-time encoded information symbols over the channels,

(c) decoding the information symbols using the initial channel estimate to produce a sequence of symbol estimates,

(d) refining the channel estimate for each channel, by processing the received symbols to remove ~~the~~an expected effect of the transmissions carried by all ~~the~~ other channels by performing cancellation using ~~the~~ relevant parts of the sequence of symbol estimates, and to remove ~~the~~an expected effect of modulation on each symbol, and by averaging the channel estimates over all symbols for each respective channel to produce a refined estimate for each channel,

(e) decoding the information symbols again using the refined channel estimate, to produce a refined sequence of coded symbol estimates, and

(f) repeating steps (d), (e) and (f) until convergence.

11. (original) A method according to claim 10, wherein the decoding step includes performing hard decoding to produce hard symbol estimates.

12. (original) A method according to claim 10, wherein the decoding step includes performing soft decoding by producing a sequence of coded symbol probabilities which are then used to calculate symbol estimates in the form of a sequence of coded symbol averages.

13. (original) A method according to claim 12, wherein after convergence, the coded symbol probabilities calculated in the last decoding step of the iteration loop are output for feeding to the input of the next decoder in a serially-concatenated decoder arrangement.

14. (original) A method according to claim 10, wherein after convergence, hard decisions on the information symbols are made using the final channel estimate.

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15. (original) A method according to claim 10, wherein after convergence, the information bits are decoded using the final channel estimate.

16. (original) A method according to claim 10, wherein the initial estimate is generated based on a relatively short, transmitted pilot or training sequence.

17. (currently amended) A method according to claim 10, wherein the information symbols are modulated using a constant modulus modulation and wherein the expected effect of the modulation is removed by multiplying a symbol with ~~the~~a complex conjugate of the average symbol for that channel.

18. (original) A method according to claim 17, wherein the symbols are PSK modulated.

19. (currently amended) Channel estimation apparatus for a space-time communications system comprising:[[-]]

(a) an initial estimator operable to generate an initial~~, relatively coarse~~ estimate of channel gain,

(b) a receiver operable to receive space-time encoded information symbols,

(c) a decoder operable to produce a sequence of coded symbol estimates using a channel estimate, and

(d) estimate refining means operable to refine the channel estimate for each channel, by processing the received symbols to remove the expected effect of the transmissions carried by all the other channels by performing cancellation using the relevant parts of the sequence of symbol estimates, and to remove the expected effect of modulation on each symbol, and by averaging the channel estimates over all symbols for each respective channel to produce a refined estimate for each channel,

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the apparatus being arranged to iteratively repeat the refining of the channel estimation and the production of symbol estimate functions until convergence of the channel estimates occurs.

20. (original) Apparatus according to claim 19, wherein the decoder is operable to perform hard decoding to produce hard symbol estimates.

21. (original) Apparatus according to claim 19, wherein the decoder is operable to perform soft decoding by producing a sequence of coded symbol probabilities which are then used to calculate symbol estimates in the form of a sequence of coded symbol averages.

22. (original) Apparatus according to claim 21, wherein the decoder is operable to output the coded symbol probabilities for feeding to the input of the next decoder in a serially-concatenated decoder arrangement.

23. (original) Apparatus according to claim 19, wherein the decoder is arranged to produce hard decisions on the information symbols using the final channel estimate.

24. (original) Apparatus according to claim 19, wherein after convergence, the decoder is operable to decode the information bits using the final channel estimate.

25. (currently amended) A computer program which, when executing on suitably configured hardware, causes the hardware to perform the steps of:[[-]]

(a) generating an initial~~, relatively coarse~~ estimate of channel gain,

(b) receiving space-time encoded information symbols over the channels,

(c) decoding the information symbols using the initial channel estimate to produce a sequence of symbol estimates,

(d) refining the channel estimate for each channel, by processing the received symbols to remove the expected effect of the transmissions carried by all the other channels by performing cancellation using the relevant parts of the sequence of symbol estimates, and to remove the expected effect of modulation on each symbol, and by averaging the channel estimates over all symbols for each respective channel to produce a refined estimate for each channel,

(e) decoding the information symbols again using the refined channel estimate, to produce a refined sequence of coded symbol estimates, and

(f) repeating steps (d), (e) and (f) until convergence.

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26. (original) A communications system arranged to use space-time coding, and comprising transmitter apparatus and receiver apparatus, the transmitter apparatus further comprising an input, a trellis encoder, a de-multiplexer, and a plurality of signal outputs wherein

the input is operable to receive a stream of data,

the trellis encoder is operable to encode the data and is operable to output encoded data, and to map the encoded data to the de-multiplexer, the de-multiplexer is operable to switch signals to the set of signal outputs, and wherein the trellis encoder comprises a convolutional encoder operable to sequentially group data to provide coded bits which encoded data is mapped to provide modulated symbols.

27. (currently amended) A system according to claim 26, wherein the receiver apparatus includes:[[-]]

(a) an initial estimator operable to generate an initial~~, relatively coarse~~ estimate of channel gain,

(b) a receiver operable to receive space-time encoded information symbols,

(c) a decoder operable to produce a sequence of coded symbol estimates using a channel estimate, and

(d) estimate refining means operable to refine the channel estimate for each channel, by processing the received symbols to remove the expected effect of the transmissions carried by all the other channels by performing cancellation using the relevant parts of the sequence of symbol estimates, and to remove the expected effect of modulation on each symbol, and by averaging the channel estimates over all symbols for each respective channel to produce a refined estimate for each channel,

the apparatus being arranged to iteratively repeat the refining of the channel estimation and the production of symbol estimate functions until convergence of the channel estimates occurs.

28. (currently amended) A communications system arranged to use space-time coding, and comprising transmitter apparatus and receiver apparatus, wherein the receiver apparatus includes:[[-]]

(a) an initial estimator operable to generate an initial~~, relatively coarse~~ estimate of channel gain,

(b) a receiver operable to receive space-time encoded information symbols,

(c) a decoder operable to produce a sequence of coded symbol estimates using a channel estimate, and

(d) estimate refining means operable to refine the channel estimate for each channel, by processing the received symbols to remove the expected effect of the transmissions carried by all the other channels by performing cancellation using the relevant parts of the sequence of symbol estimates, and to remove the expected effect of modulation on each symbol, and by averaging the channel estimates over all symbols for each respective channel to produce a refined estimate for each channel,

the apparatus being arranged to iteratively repeat the refining of the channel estimation and the production of symbol estimate functions until convergence of the channel estimates occurs.

29. (original) An integrated chip programmed so as to be operable to encode a stream of data and which is operable to output encoded data wherein the chip comprises a convolutional encoder operable to sequentially group data to provide coded bits, which coded bits are mapped to provide modulated symbols which then are de-multiplexed to form space-time symbols.

30. (original) Software stored on a machine readable medium operable to encode a stream of data and which is operable to output encoded data wherein the software is programmed to function as a convolutional encoder operable to sequentially group data to provide coded bits, which coded bits are mapped to provide modulated symbols.